Occurrence of Italian earthquakes and UTC time

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Abstract

Between 2023 and 2024, some periods of the year in which many earthquakes occurred in Italy were analysed. This study considered whether there was a relationship between the UTC time of occurrence of these earthquakes and their number, to verify whether there were emerging relationships between these data and the identification of any precursory seismogenic phenomena. The analysis of the data has shown that a periodicity of the seismic occurrence can be hypothesized, at certain hours of the solar day.

Keywords: UTC Time, Italy, Earthquake, Seismic Precursors.

1 - Introduction

Between 1 March 2023 and 30 September 2023, over 10,000 earthquakes occurred in Italy [3]. This number of earthquakes highlights how Italy is one of the European countries with the greatest seismic risk, compared to other geographical areas [4]. In some areas, swarms with dozens or hundreds of seismic aftershocks occurred, causing particular panic among the Italian population.

Although the study of earthquakes is a particularly difficult area of research, given the complexity of the phenomena that determine an earthquake, in this study the times of occurrence of the earthquakes that occurred in 7 months were analysed, to understand if it was possible to identify a relationship that could help understand part of the seismogenic mechanism.

2 - Method and Data

In this study, the researchers processed the seismic data coming from the INGV - National Institute of Geophysics and Volcanology, which covered the entire Italian territory for a duration of 7 months (10,000 earthquakes), then verifying when these earthquakes occurred are presented with respect to UTC time. The question was whether UTC time can be linked to mechanisms that are able to interact on the triggering of earthquakes?

In addition to the UTC time of the earthquakes' occurrence, the researchers considered two distinct areas of Italy, namely that of the entire Italian territory and the much smaller one linked to a part of the Province of Parma, a place where, recently, it was a very particular seismic swarm.

2.1 - Temporal Context

First of all, the researchers had to consider that in Italy there are two types of timetables in force, winter time and summer time, better known as Summer Time and Solar Time. In this context, the relationship between these times and UTC time becomes more complicated, compared to other countries that do not consider a different type of time between the summer and winter seasons.

UTC (Coordinated Universal Time) does not take daylight saving time into account. In Italy, summer time applies from March to October, moving the clock forward one hour compared to UTC+1, which is Italy's standard time zone (CET - Central European Time). So, during summer time, Italy is in UTC+2.

- During daylight saving time (March-October): 1pm UTC corresponds to 3pm in Italy.
- Outside daylight saving time (October-March): 1pm UTC corresponds to 2pm in Italy.

This temporal placement allowed more precise calculations to be carried out and the results obtained are interesting. First of all, the data divided into three annual portions were considered:

- Last 7 days (February 2024).
- Last 30 days (January 2024 – February 2024).
- Last 7 months (March 2023 – September 2023).

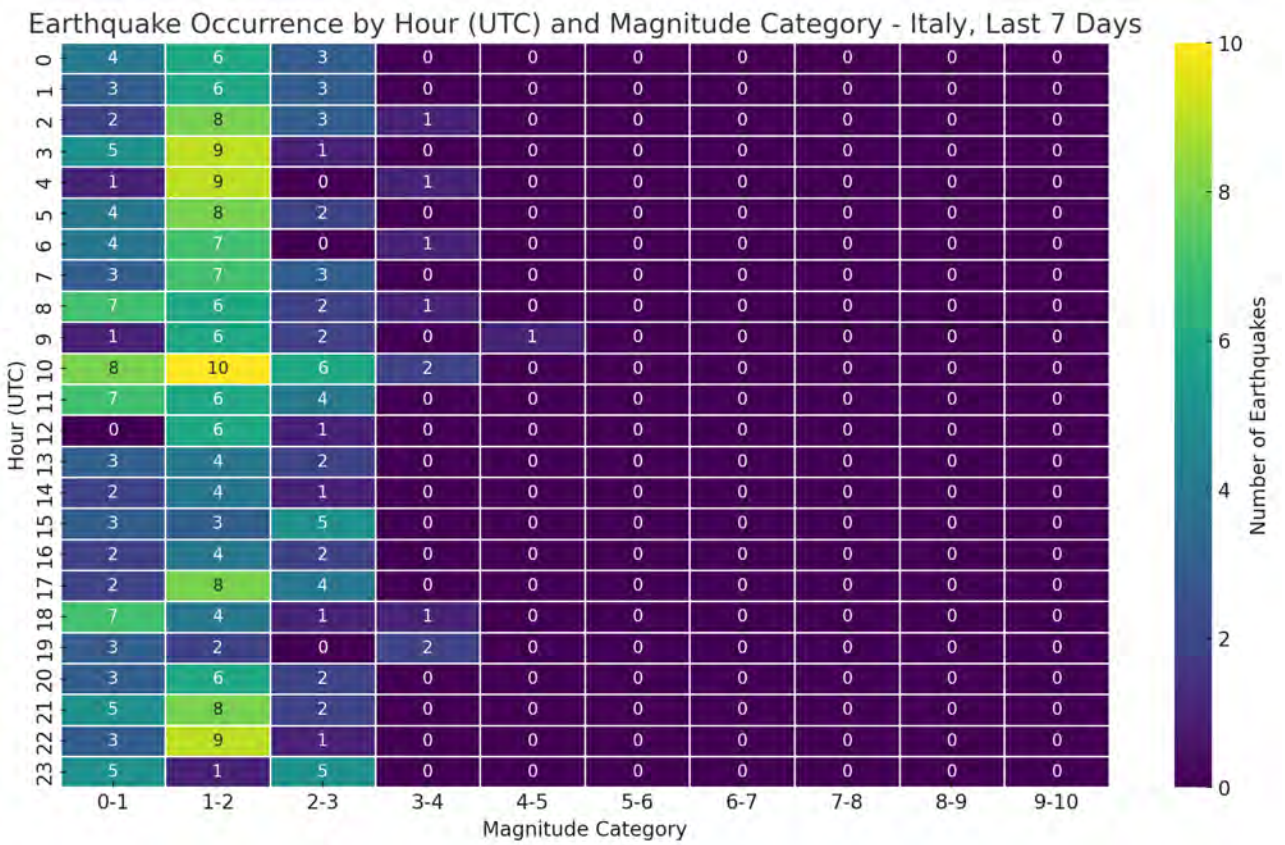

Fig. 1 – Italian seismic activity of the last 7 days: between 21 February 2024 and 28 February 2024 (7 days). The UTC time is visible on the ordinate axis and the seismic magnitude of the earthquakes that have occurred is visible on the abscissa axis. Credits: Radio Emissions Project; INGV.

To try to understand how the seismic data appeared linked to the time of occurrence, in three distinct time windows, and to understand whether there were persistent temporal relationships or not.

The first calculation carried out was that relating to the seismic activity of the last 7 days (Fig. 1), i.e. between 21 February 2024 and 28 February 2024.

The graph created shows us how there is a greater crowding of earthquakes around the hours 10:00 UTC (major earthquake peak, a second cluster between 02:00 UTC and 05:00 UTC, and a third cluster around 20:00 UTC and 22:00 UTC.

Then considering a broader time window, the researchers engaged in this study calculated the time of occurrence of earthquakes over the last 30 days (4 weeks), i.e. between 30 January 2024 and 29 February 2024, as visible in Fig. 2.

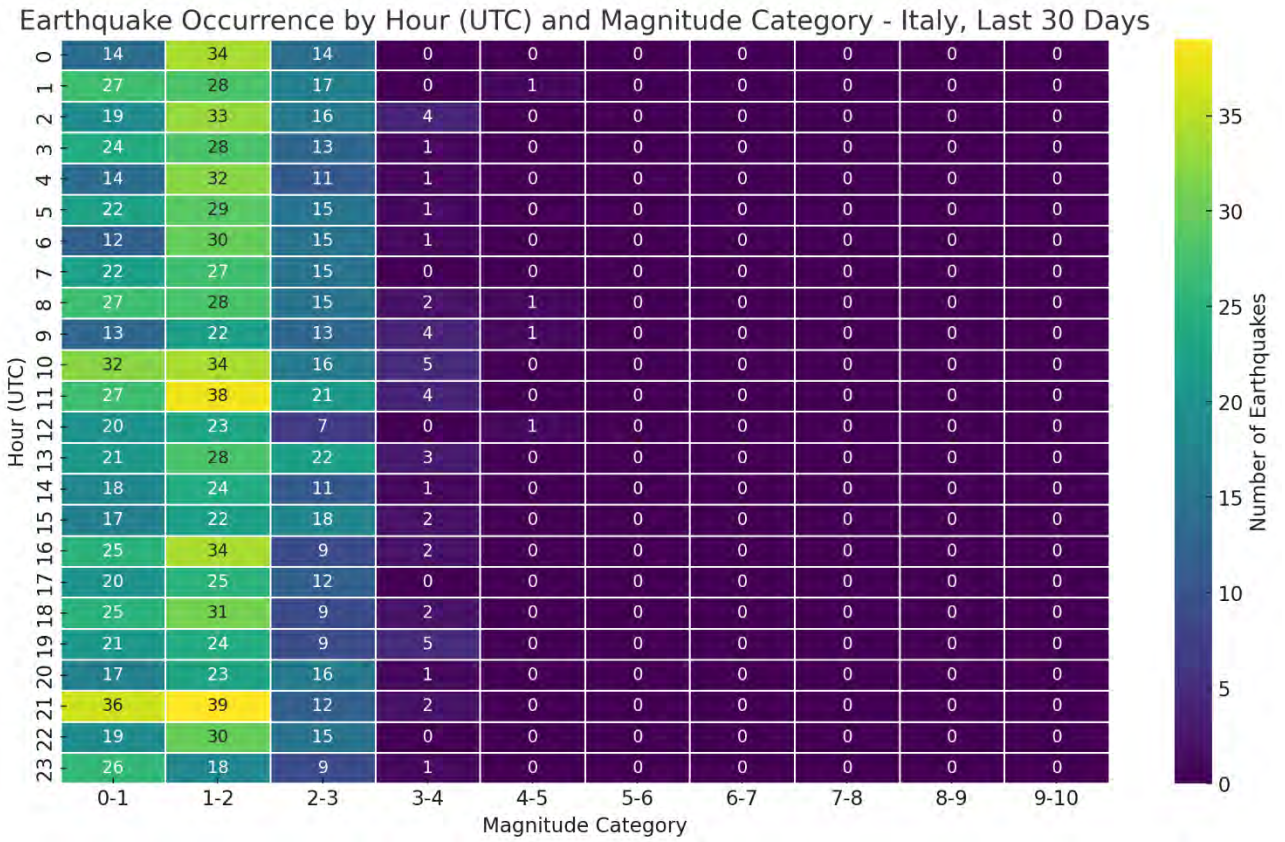

Fig. 2 – Italian seismic activity of the last 30 days: 30 January 2024 and 29 February 2024 (30 days). The UTC time is visible on the ordinate axis and the seismic magnitude of the earthquakes that have occurred is visible on the abscissa axis. Credits: Radio Emissions Project; INGV.

This graph (Fig. 2) outlines the distribution of earthquakes in a greater way, despite this, a peak of earthquakes is still observed at 11:00 UTC (second grouping), a greater peak compared to the first time window, appears at 21:00 UTC, while in the third group, the presence of several earthquakes are confirmed, between 00:00 UTC and 08 UTC.

So in this case, compared to the data of the last 7 days (Fig. 1), Fig. 2 shows in the last 30 days a greater distribution of earthquakes in the three main parts of the day. This confirmed that there was a repeating trend in the appearance of earthquakes with respect to UTC time.

This could certainly provide hypotheses so that this temporal behavior of the earthquakes that occurred in Italy could be considered in a scientific approach.

At this point, an even longer time window was considered, calculating the occurrence of Italian earthquakes over several months. This approach was the basis considered by the researchers to understand whether the trend of earthquake occurrence maintained its occurrence.

We then considered a duration of 7 months (10,000 earthquakes) which occurred between 1 March 2023 and 31 September 2023.

The data obtained from the 7-month time window (Fig. 3) showed further variations, but also confirmations. The researchers found that there are three main groupings regarding the time of occurrence of earthquakes:

1. 07:00 UTC – 08:00 UTC
2. 15:00 UTC – 16:00 UTC
3. 21:00 UTC – 03:00 UTC

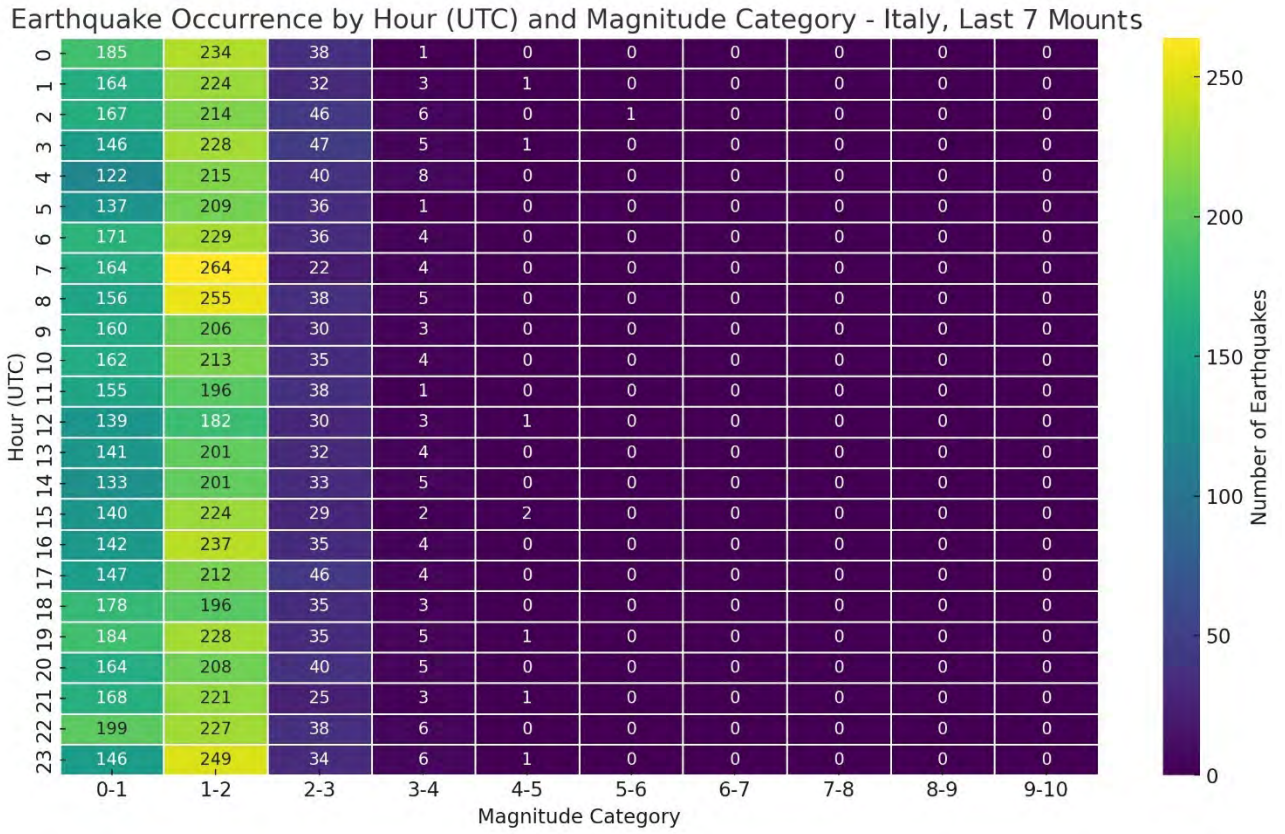

Fig. 3 – Italian seismic activity of the last 7 months, between 1 March 2023 and 30 September 2023 (213 days). The UTC time is visible on the ordinate axis and the seismic magnitude of the earthquakes that have occurred is visible on the abscissa axis. Credits: Radio Emissions Project; INGV.

From the analysis of the data it emerged that the Italian earthquakes, observed in 7 months of 2023, saw a greater occurrence between night times, close to sunset and dawn, and a smaller percentage, albeit emerging, in central time, that is, when the Sun seems higher in elevation.

A further investigation concerned a potential direct relationship between the position of the Sun, the time of occurrence and the number of earthquakes, on particular Italian seismic events.

In this regard, it was verified whether this occurrence could be applied to a recent earthquake swarm in the province of Parma, between 1 October 2023 and 29 February 2024 (Fig. 4).

The data from the Parma seismic swarm again showed a trend in the occurrence of seismic events distributed across three main groupings, which in this case were the following:

1. 13:00 UTC
2. 05:00 UTC – 06:00 UTC
3. 20:00 UTC – 22:00 UTC and 22:00 UTC – 00:00 UTC

This grouping is in line with what was observed not only in the data observed in the national time window of the last 7 days, the last 30 days and the last 7 months, but also for this particular seismic swarm.

3 - Discussion.

The first and only factor that seems to correlate at least hypothetically to the seismogenic mechanism is the position of the Sun, with respect to Italian UTC time.

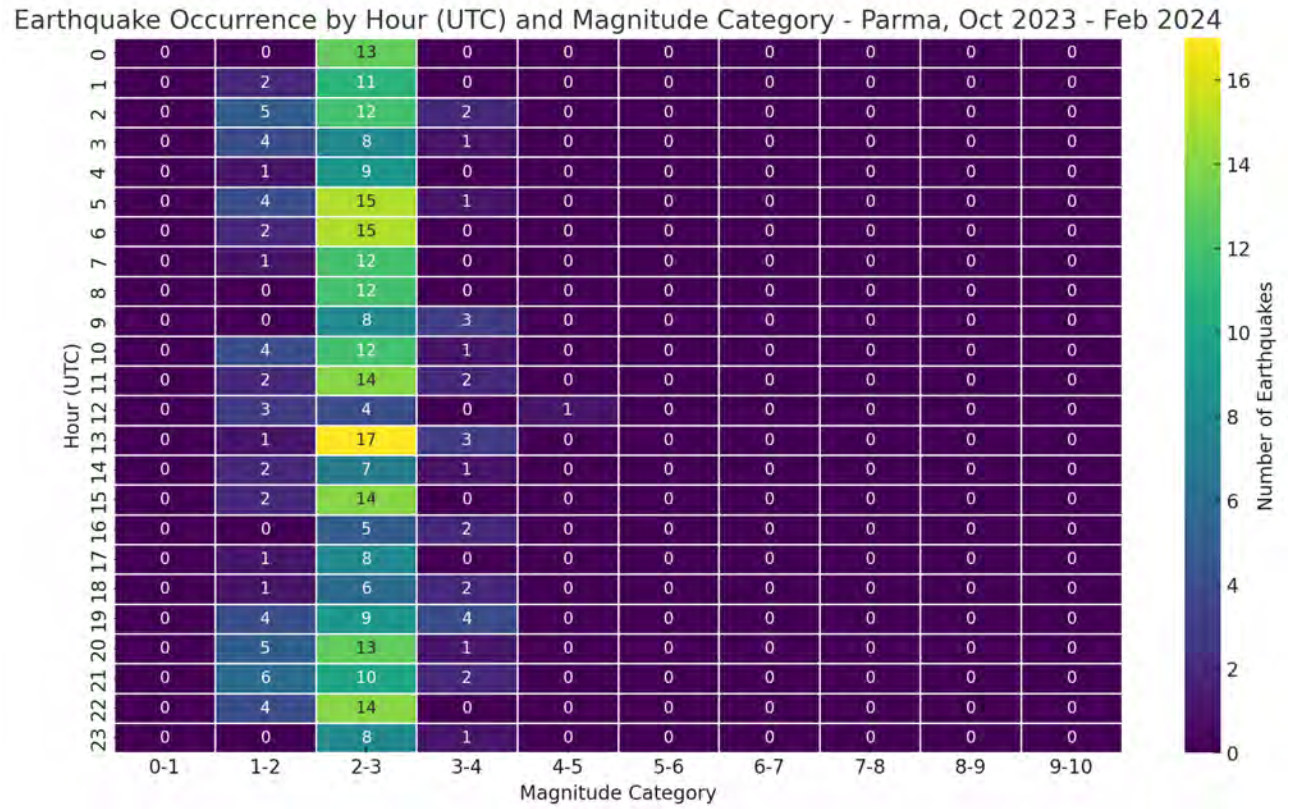

Fig. 4 – Italian seismic activity in the province of Parma, between 1 October 2023 and 29 February 2024 (151 days). The UTC time is visible on the ordinate axis and the seismic magnitude of the earthquakes that have occurred is visible on the abscissa axis. Credits: Radio Emissions Project; INGV.

This means that when the earthquakes observed throughout Italy and in the province of Parma occur, the Sun is in precise positions, with respect to UTC time and with respect to the position of Italy itself.

As we know, the Earth rotates on itself, rotating the Earth's surface from East to West, exposing the entire Earth's surface to sunlight, starting from the East, to the West.

At any point on Earth, if we observe the Sun, we can see it rising in the East and setting in the West, this is very important because it is a cyclical trend, just as the times of occurrence of earthquakes seem to be cyclical.

But what happens to the Earth's surface when it is illuminated by the Sun? Tidal forces act not only on the oceans but also on the solid Earth, causing small but measurable deformations. These deformations can affect seismic faults in several ways [1]:

- Altering fluid pressure: Tidal forces can cause changes in fluid pressure within porous rocks, affecting the lubrication of faults and potentially making them easier to slide.

- Stress variations in the Earth's crust: Deformations caused by tidal forces can alter the state of stress along faults, potentially bringing some areas closer to the failure threshold and inducing earthquakes.

- Effects on magma: As it directly concerns the tide of magma, changes in pressure due to tidal forces can influence the movement of magma underground, potentially impacting volcanic activity. This, in turn, can alter the state of stress in the vicinity of seismic faults.

- Earthquake triggering: Some data [1] suggest that tidal forces may play a role in triggering earthquakes, especially in areas already close to the rupture threshold.

A recent study [1] has related the position of the Sun to the occurrence of earthquakes, in this context, in this case it is conceivable that the action of the gravitational attractiveness of our star may have interacted with the instability of the Italian faults, determining their trigger and subsequently releasing energy and therefore causing earthquakes.

If we see the position of the Sun, we can certainly understand that in the central times, which emerged from the study of the occurrence of earthquakes, the Sun is at the highest point in the sky, if observed from Italy, and this could indicate precisely the push magmatic tide more intense than at other times, in which the Sun is at a lower elevation (just as happens for normal marine tides), as regards the data on the occurrence of earthquakes in the early hours of the morning or in the early hours of night, we can certainly hypothesize that in this case these areas are in the transition area between the part illuminated by the Sun and the part in the shadow and this could determine, due to the temperature variation, a release of the faults which present greater mechanical stress, in in this context the gravitational force could play an important role because the gravitational lines of force would be practically parallel to the surface of the ground and this crustal traction would be more effective than the gravitational attraction carried out with a different solar (gravitational) angle.

In essence, this study could hypothesize the existence of a direct relationship between gravitational forces and their angle of interaction, with respect to the Earth's surface, a phenomenon that would be reflected in the stability of the faults and layers of the crust itself.

However, when the occurrence of earthquakes occurs close to Italian midnight, this means that the gravitational interaction is also reflected with the Sun in the opposite position with respect to its zenith, i.e. the forces that come from the nadir, where the Sun is in that moment, and in this case, as for the case in which the Sun was at the zenith, the gravitational forces would be practically almost perpendicular, determining greater force to the lifting of the Earth's crust or to its sinking, depending on where the Sun is located [1].

In Fig. 5 we can schematize the gravitational interaction between the Earth and the Sun at the crustal level. At points A, B and C, the differences of this interaction:

A. Italy is located on the terrestrial terminator, i.e. that area where we pass from the illuminated portion of the earth's surface to the shaded one. In this case, a new increase in the number of earthquakes is noted (evening or morning hours in the hours close to local sunset or dawn). In this case the gravitational force is parallel to the Earth's surface.

B. Italy is located in a median position between the solar Zenith and the terrestrial terminator, at this time (time window) not many earthquakes occur. Gravitational interaction appears not to interact well with the instability of seismic faults.

C. Italy is located in the part illuminated by the Sun and at the zenith, and its interaction is direct and maximum at tidal level (magma). At this time, more earthquakes appear to occur (local midday). In this case the gravitational force is perpendicular to the Earth's surface.

The diagram also shows the position of the Sun at our Italian nadir, in this case Italy is subject to the nadiral gravitational force which causes the surface of the Earth's crust to "sink", interacting, albeit to a lesser extent, compared to when the Sun is to the Italian zenith.

In this case, the gravitational force is perpendicular to the Earth's surface.

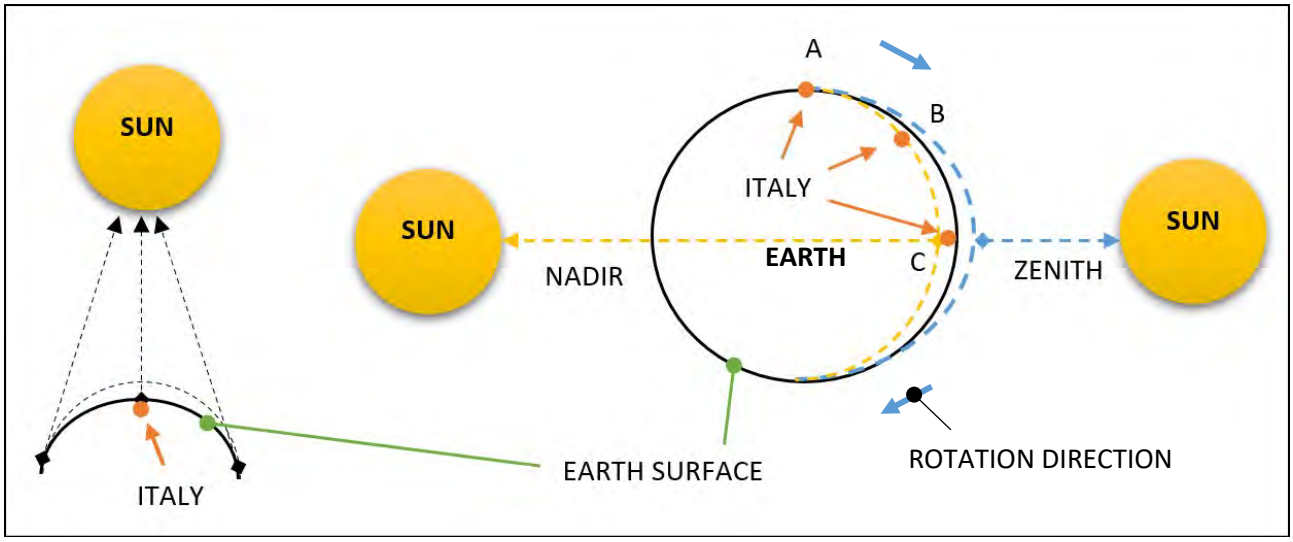

Fig. 5 – Schematization of the gravitational interaction between Earth and Sun. Credits: Radio Emissions Project.

According to some studies [2] the Earth is deformable and cannot be assimilated to a non-deformable globe, it has been observed that gravitational activity constantly deforms the planet.

This would therefore imply serious hypotheses that would justify how earthquakes can occur on a surface (crust) deformable by gravitational interactions.

From this point of view there are important indications that earthquakes are influenced by gravitational effects [5] and that therefore the cyclical observation that these occur at certain times, with respect to their geographical location, is also related to gravitational phenomena whose interactions are obviously cyclical.

It is crucial to consider that earthquakes are natural phenomena whose occurrence is primarily determined by geological factors internal to the Earth (energy), so there are many other aspects that should be considered and which for the most part are not possible to document.

In this context, in relation to the temporal context this can be considered for each type of geographical area individually, since the UTC time is distributed along the earth's surface and therefore an area that is too large would provide data that is too variable and not indicative.

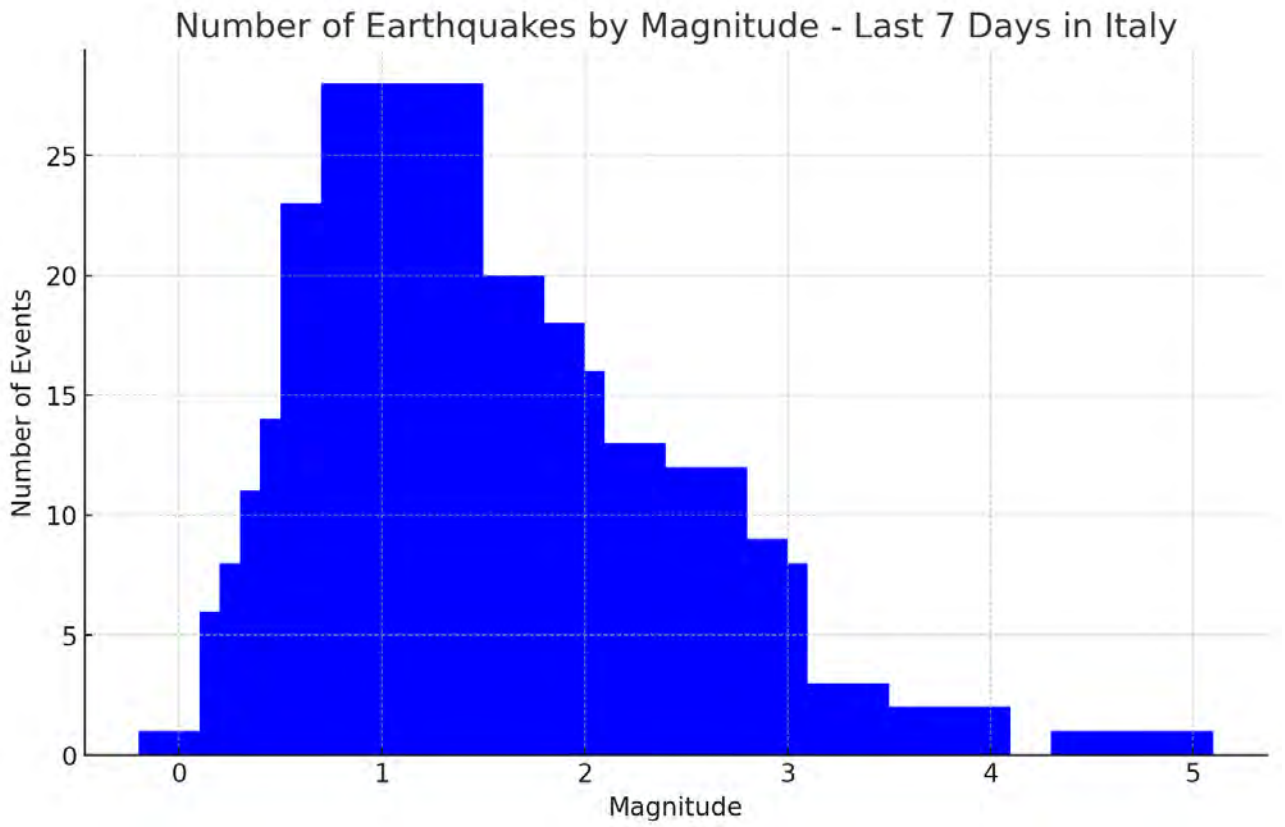

Fig. 6 – Pattern relating to the trend of the number of earthquakes and their magnitude in Italy, lasting 7 days: from 21 February 2024 and 28 February 2024 (7 days). The number of seismic events is visible on the ordinate axis, and the magnitude of the individual seismic events considered is visible on the abscissa axis. Credits: Radio Emissions Project; INGV data.

Another interesting data is the pattern of the distribution of earthquakes with respect to their magnitude, on Italian territory and that of the province of Parma, compared to the same time areas (Fig. 8, 9, 10 and 11).

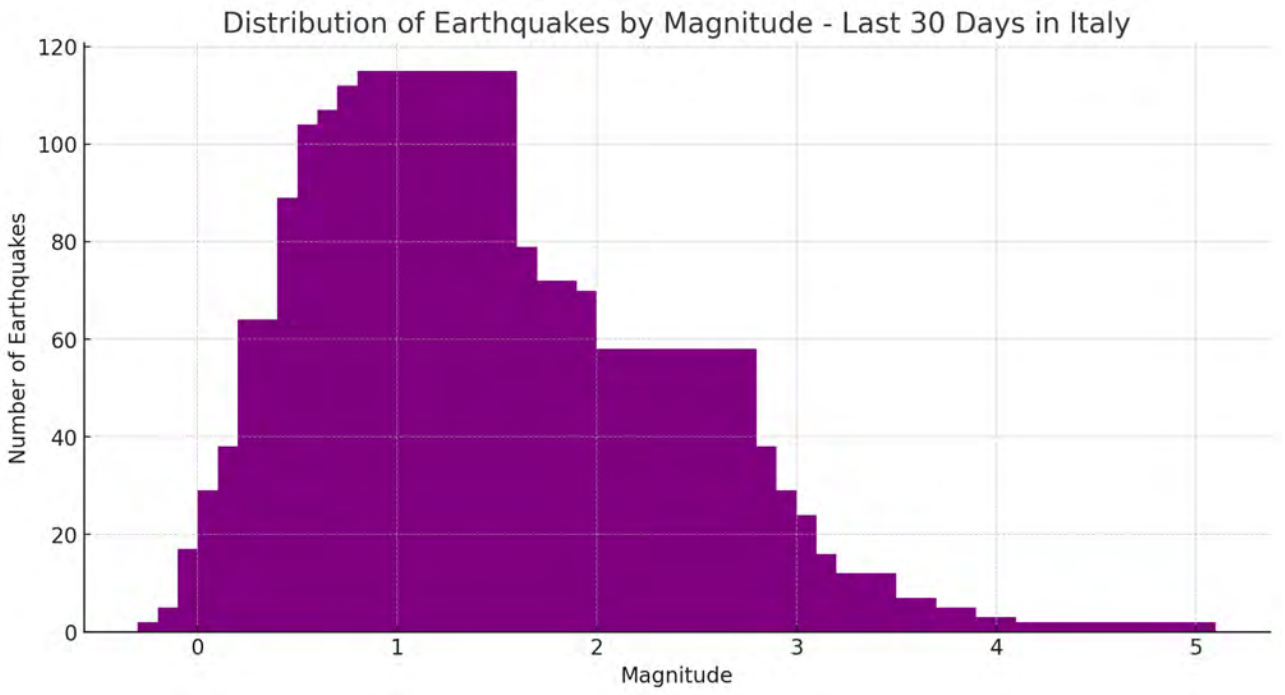

Fig. 7 – Pattern relating to the trend of the number of earthquakes and their magnitude in Italy, lasting 30 days: from 30 January 2024 and 29 February 2024. (30 days). The number of seismic events is visible on the ordinate axis, and the magnitude of the individual seismic events considered is visible on the abscissa axis. Credits: Radio Emissions Project; INGV data.

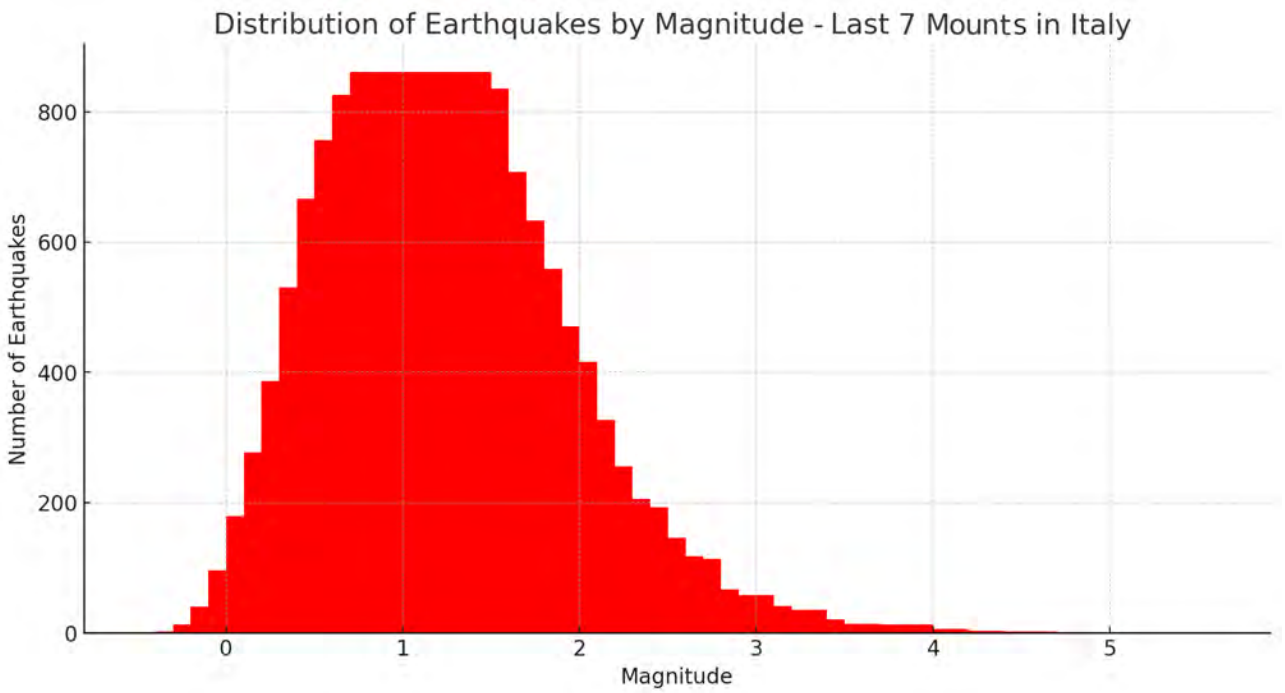

Fig. 8 – Pattern relating to the trend in the number of earthquakes and their magnitude in Italy, lasting 7 months: from 1 March 2023 to 30 September 2023 (213 days). The number of seismic events is visible on the ordinate axis, and the magnitude of the individual seismic events considered is visible on the abscissa axis. Credits: Radio Emissions Project; INGV data.

Considering a longer time duration we notice a greater number of earthquakes at very low magnitudes (Fig. 10), with a peak within the 7 months considered which varies between the seismic magnitude ML1 and ML 1.5.

If we analyze the data of the last 30 days, it emerges that the pattern is on the same seismic magnitude, with a greater peak between ML1 and ML1.5. (Fig. 9).

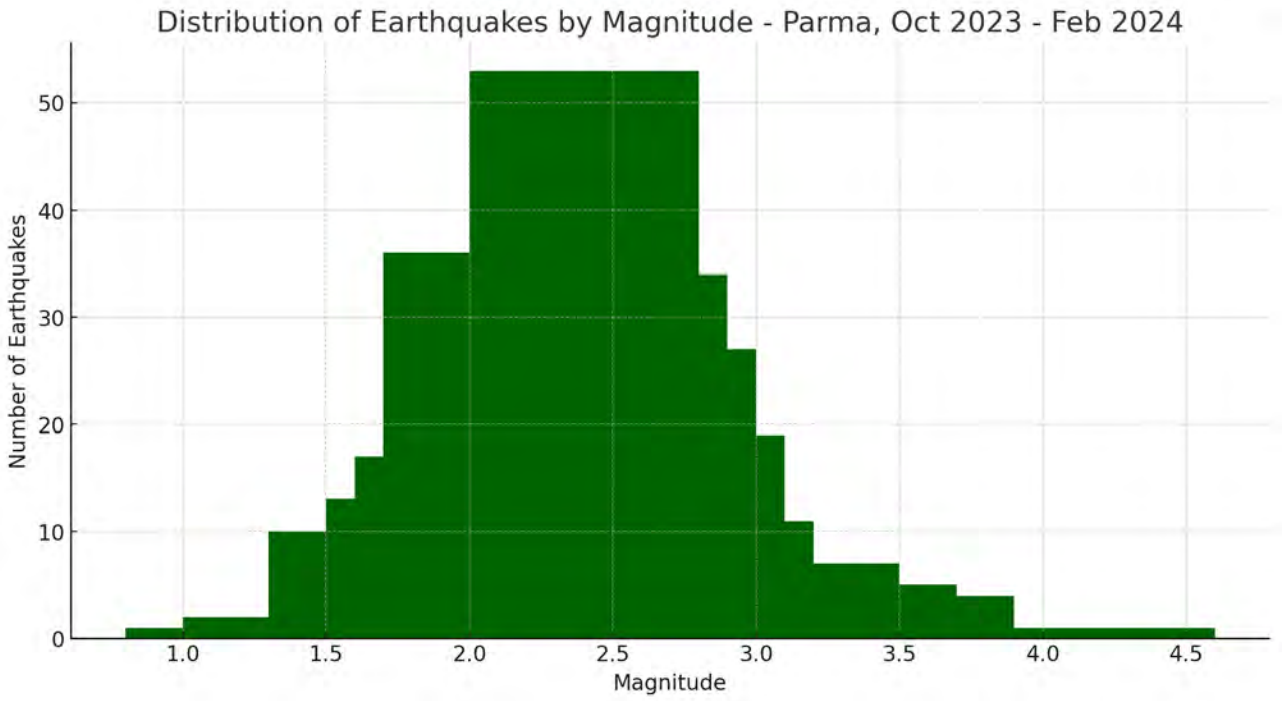

Fig. 9 – Pattern relating to the trend of the number of earthquakes and their magnitude in the province of Parma: from 1 October 2023 and 29 February 2024 (151 days). The number of seismic events is visible on the ordinate axis, and the magnitude of the individual seismic events considered is visible on the abscissa axis. Credits: Radio Emissions Project; INGV data.

Considering the seismic pattern of the last 7 days, the seismic magnitude has a peak in the same point, i.e. between a magnitude ML 1 and ML 1.5. (Fig. 8).

However, the trend of the seismic event observed in the province of Parma was different and was characterized by a significant seismic swarm. In this case the local seismicity pattern with a radius of 50 km from Parma shows a seismic magnitude between ML 2.0 and ML 2.8. (Fig. 11).

This shows that the seismic trend observed in this area (Parma) was characterized by an increase in seismic magnitude compared to the Italian average, from 1 October 2023 to 29 February 2024 (151 days), an increase in magnitude also visible on Fig. 8 and 9, as a slight increase in the number of earthquakes with magnitudes between ML 2 and ML 3.

Such observations indicate that the energy system complies with the "Gutenberg-Richter Law". This empirical law describes the relationship between the magnitude of earthquakes and their frequency in a given area and period of time. Essentially, the law states that for every unit increase in magnitude, the number of earthquakes decreases by a factor of about ten times. This means that earthquakes of smaller magnitude are much more frequent than those of larger magnitude.

As regards the trigger phenomena hypothetically generated by the Sun, especially during daylight hours, as observed by the number of earthquakes observed especially in the time between 13:00 UTC and 15:00 UTC, we can consider how the Sun is capable of propagate its energy towards the Earth and that constant flow of energy is enormous.

Changes in the Earth system's atmosphere, hydrosphere, biosphere, and lithosphere (sedimentary rocks) depend on the continuous stream of particles flowing outward from the Sun.

- The Sun loses about 5.5 million tons of mass every second, or about 174 trillion tons of mass every year [6]. The radiation pressure of sunlight on the earth is equivalent to that exerted by approximately one thousandth of a gram on a surface of 1 square meter (measured in units of force: approximately 10 μN/m2). Considering the Earth's surface: 510,072,000 km², the total pressure acts on the Earth's surface with a force of many billions of kg/force per year. Therefore, solar radiation reaching the Earth's upper atmosphere exerts a pressure (force) of sufficient magnitude to disturb the balance of the Earth's tectonic plates.

- The continuous flow of solar particles (solar wind) pushes the Earth's magnetic field. As a result, the geomagnetic field, acting as an electromagnetic barrier, is compressed in the direction towards the Sun and stretches into a (tail) in the direction away from the Sun. Fluctuations in its speed, density, direction and entrained magnetic field strongly affect the Earth's local space environment. The pressure of the solar wind on Earth's magnetic field compresses the field on Earth's dayside and stretches the field into a long tail on the nightside. On the dayside of the Earth, rather than extending to infinity, the magnetic field is confined to within about 10 Earth radii of the Earth's center, and on the night side, the field is extended to hundreds of Earth radii, well beyond the Earth's orbit. The interaction between the solar wind and the Earth's magnetic field, and the influence of the underlying atmosphere and ionosphere, creates various regions of fields, plasmas and currents within the magnetosphere such as the plasmasphere, ring current and belts of radiation [6], and this can certainly interact with the forces at play at the magnetic and electrical level (Lorentz Force, capable of destabilizing seismic faults.

- Changes in gravity also deform the Earth and cause earthquakes. Einstein imagined gravity as a deflection of space-time caused by mass. The geodetic effect is the deformation of space

and time by the gravitational field of a massive body (in this case, the Earth). The G.R.A.C.E. satellite (Gravity Recovery and Climate Experiment) detected a migration pattern of gravity changes due to deep crustal processes a few months before the 2011 Tohoku (Japan) earthquake. [6] Most earthquakes occur along the edge of oceanic and continental plates. Sediment transport is the movement of solid particles due to a combination of gravity acting on the sediment and movement of the fluids in which the sediment is entrained. The force of gravity acts to move the particles along the inclined surface on which they rest. Sediment transport due to fluid movement occurs in rivers, oceans, lakes, seas and other bodies of water [6] [7].

- The gravitational interaction on the earth's surface (stretching effect) considered in this study (see Fig. 4 position “A” of Italy on the earth's surface), can interact with the faults by stretching them even by a few mm on a long portion of the fault hundreds of km. The separation of a few mm per day allows debris, water and crystalline deposits to penetrate the seismic faults and settle between the fault surfaces, effectively separating them more and more with each cyclical passage of the Sun. (area of the earth's terminator), at this point the temperature of the earth's surface would also play a fundamental role, deforming these surfaces even more under the influence of solar radiation, increasing their temperature, and then decreasing again when the solar radiation illuminates the cell the earth's surface. This phenomenon of increase and decrease of the earth's crust would allow debris and water to deposit cyclically, effectively destabilizing the faults within them.

4 - Conclusion

It is concluded that the major earthquakes occur at certain times compared to others, and this occurrence is repeated in different periods considered, obviously with variations due to the number of earthquakes that occurred in each individual period.

This could suggest the hypothesis that there may be an interaction between seismogenesis and some other mechanism, partly conceivable which seems to have a cyclical behaviour.

The tidal effect tends to raise the earth's crust and with it to destabilize the faults, especially during the daytime hours when the Sun is at its maximum elevation and this also explains why the majority of earthquakes are found along the area most illuminated by the Sun (tectonic equator).

Credits

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